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ABSTRACT

A project was conducted to develop energy instructional units which would fit into each year of a three-year farm business management curriculum. Four curriculum units which focus on fertilizer management in crop production were developed. The first unit was designed to develop farmers' awareness of energy as a vital resource to their businesses and the establishment of farm and family goals. The second unit was designed to describe the amount of energy needed to produce fertilizer for the farming operation. The third and fourth units were designed to describe energy consumption and returns from the various cropping programs and methods of planning a cropping program which encourages energy conservation. (A copy of the four units are contained in the appendices. Each unit contains student objectives, and suggested teaching strategies.) (JH)

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ED174780

FINAL REPORT

PROJECT NUMBER 3-CD-79

AGRICULTURAL ENERGY CUR..CULUM DEVELOPMENT PROJECT

Research and Development Project

in Career Educational

Vocational

Conducted Using Funds Provided by the
Division of Vocational-Technical Education
Minnesota Department of Education
Under Subpart 3, Program Improvement and
Supportive Services, PL 94-482

The project reported herein was performed pursuant to a contract from the Division of Vocational-Technical Education, Minnesota Department of Education. Contractors undertaking such projects under Division sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions stated, therefore, do not necessarily represent official Division position or policy.

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July 19, 1979

CE022182

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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APPENDICES:

A. PROPOSAL

B. AGRICULTURAL ENERGY CURRICULUM (3 copies)

Check Type of Report
☐ Interim
☒ Final

ABSTRACT

Minnesota State Department of Education

Submitted by: Research Coordinating Unit For Vocational Education

Date of Preparation 7/19/79

DIVISION OF
VOCATIONAL-TECHNICAL EDUCATION

Check One:
☒ Approved Contract..... State Contract No.: 472274-141309-270 (3-CD-79)
☐ In-House..... State Project No. :

Project Title: AGRICULTURAL ENERGY CURRICULUM

Principal Investigator
and Organization: MARLIN WACHOLZ, GRANITE FALLLS AVTI, HWY 212 WEST,
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☐ Other: _____ (Source) _____ (Amount) Charged to Fiscal Year _____

OBJECTIVES: Develop an energy instructioanl unit which will fit into each year of the three year Farm Business Management curriculum. The lessons will focus on fertilizer management in crop production. Fertilizer was chosen because of its energy impact, it is a large cost element to most farmers, it is specically addressed in the first year unit of the program, and data on fertilizer, yields and energy equivalents are available.

PROCEDURES: A curriculum development person was contracted to review the liturature on the subject of fertilizer and energy; to develop a curriculum to be added to the three years of the Farm Management Curriculum which contains information on fertilizer and energy.

EXPECTED CONTRIBUTION OR POTENTIAL IMPACT ON VOCATIONAL EDUCATION:
This project will develop energy awareness in Vo-Ag instructors and provide them with information to disseminate to farm business managers which will strngthen their bysiness and help them to conserve energy in their fertility program.

PRODUCT(S) TO BE DELIVERED: Four curriculum seg ments which can be included in the three years of the farm management curriculum.

I. As stated in the proposal, there is a need at the present time to disseminate to farmers information on the energy demands and returns of production agriculture, specifically in the area of fertilizer usage.

This project was to fill this need by developing a curriculum segment for the adult farm business management program which deals with the topic of fertilizer energy.

Since there is already a statewide network of adult instructors for providing farmers with the information, provision of a curriculum for use in this program was felt to be an economic and effective method of disseminating energy information.

II. A person familiar with the development of the original farm management curriculum was contracted to develop the fertilizer energy segment. The intent was to adapt the energy curriculum to the format of the existing two volumes of the farm management curriculum and to the format of the third volume which is presently being revised.

The Granite Falls AVTI served as the fiscal agent for the contracting of Jim Warner who had previously taught farm management at the school. He is presently working with Dr. Edgar Persons on the revision of volume three of the curriculum.

A review of pertinant literature was conducted. Interviews with researchers and extension personnel working with energy and fertilizer were conducted as well. Meetings were held with vocational agriculture farm management advisory people to identify specific needs which they might have on the subject of fertilizer energy which could be satisfied through the project.

A rough draft of the curriculum was reviewed by Dr. Edgar Persons, principle author of the first two volumes of the farm management curriculum. Changes were made to make it more adaptable to the existing curriculum.

Copies of the final draft were presented to the state supervisory staff of the vocational farm management program, the Granite Falls AVTI and the Director of the Minnesota Energy Agency.

III. The final product of the project, three (3) copies of which are enclosed, is a 23 page, four segment addition to the farm management curriculum.

The segments of the curriculum begin with the development of the farmers awareness of energy as a vital resource to their business and the establishment of farm and family goals which are consistent with energy conservation. The

next segment describes the abount of energy needed to produce fertilizer for the farming operation. The third and fourth segments concentrate on energy consumption and returns from the various cropping programs and methods of planning a cropping program which encourages energy conservation.

These segments can be taught as part of the existing units on cropping programs or can be utilized as a separate unit which covers only the energy aspect of the cropping program.

Additional curriculum development is recommended in the areas of tillage, livestock production, agricultural mechanics and crop drying systems. This would help to offset increasing demand for energy by farmers in a time of decreasing supplies.

IV. Budget:

The following disbursements were made by the Granite Falls AVTI in connection with this project.

		Budgeted	Disbursed
Salary:	James C. Warner	$1500	$1500
Milage & Travel:	James C. Warner	300	300
Typing:	James C. Warner	200	200
		$2000	$2000
		Net	-0-

Proposal
ENERGY CURRICULUM
For
Farm Business Management
A course of study for adults

Background -Agricultural production represents 3-4% of the total energy use in Minnesota. This may be a small part of the energy used, but it is very important. First of all, agriculture is reliant on energy for machinery and livestock operation and for the production of farm inputs. Fertilizer is farming's largest energy consumer representing one-third of the energy used in agricultural production.

Secondly, 40% of Minnesota's economy is agriculturally related. Obviously, addressing energy in agricultural decisions may ease potential problems for farmers and the state's economy. The adult Farm Business Management Program with its 130 Adult Instructors is an excellent way to reach Farm decision makers.

Purpose -To make farmers aware of the energy impacts of their decisions. Encourage Farmers to measure their energy use. Provide information on how they can consider energy in their management decisions.

Overall Objective -Develop an energy instructional unit which will fit into each year of the three year Farm Business Management curriculum. The lessons will focus on fertilizer management in crop production. Fertilizer was chosen because of its energy impact, it is a large cost element to most farmers, it is specifically addressed in the first year unit of the program, and data on fertilizer, yields and energy equivalents are available.

Detailed Objective -The instructional unit will define basic energy concepts, describe the amount of energy used in the manufacturing of fertilizer, and identify the energy impacts of fertilizer usage.

The placement of the unit will be in the three year Farm Business Management Curriculum. This curriculum is used in the ongoing Farm Business Management Program which uses Adult Vocational Agricultural Instructors to reach Farmers.

Distribution of the written instructional unit will be to the 130 Adult instructors of the Farm Business Management Program at their summer workshop.

Inservicing will be provided to instructors at their summer Vocational Agriculture Workshop. This proposal includes all preparatory work for the workshop inservicing.

Future efforts would be similar units, developed on other farm subjects for use in the second and third year programs. These subjects include farm vehicles, tillage, crop dying, feed handling, waste disposal, water heating, ventilation, and space heating.

COSTS

STAFF	15 days x $100 aday	=	1500
TRAVEL			300
Typing			200
			$2,000

ADDENDUM TO FARM AND RANCH

MANAGEMENT CURRICULUM, VOLUMES I, II AND III

FERTILIZER ENERGY DEMANDS AND CONSERVATION IN PRODUCTION AGRICULTURE

BY

JAMES C. WARNER

JUNE, 1979

The amount of energy consumed on U. S. farms over the past twenty years has also changed. As noted in table 2a the amount of energy consumed in agricultural production and its inputs in 1970 has increased to 1.75 the amount consumed in 1950. Energy consumed as fertilizer has increased by 3.9 times over the same time period.

TABLE 2a. ENERGY CONSUMED IN AGRICULTURAL PRODUCTION (1)
Values are multiplied by 10^{12} kcal.

	1950	1970
Fuel (Direct Use)	158.0	232.0
Electricity	32.9	63.8
Fertilizer	24.0	94.0
Agricultural Steel	2.7	2.0
Farm Machinery	30.0	80.0
Tractors	30.8	19.3
Irrigation	25.0	35.0
	303.4	526.1

(1) Adapted from Steinhart, John S. Energy Use in the U. S. Food System. Science, Vol. 184, Washington, D. C., 1974, p. 309

Over the period from 1960 to 1970 we find that the energy used for food production as a percentage of the total energy consumed in the U.S. did not change significantly. Farming utilized less than one-fortieth of the nations energy in 1970 compared to automobiles which utilized one-seventh of the nations energy in the same year. (2)

Since energy costs have increased rapidly in the last several years when compared to other production inputs, the costs of the inputs directly related to energy costs have increased faster than the overall trend in production costs. Agriculture consumes more petroleum, directly and indirectly than any other industry. (3) It is therefore subject to short supply and increasing prices unless farm policy favors agriculture energy needs.

(2) Gostovich, John. Farm Energy During an Era of Scarcity, Minnesota Agricultural Economist, University of Minnesota, St. Paul, 1975
(3) Perelman, Michael J. Farming With Petroleum, Environment, Vol. 14, No. 8, St. Louis, Mo. 1972

RATE YOUR GOALS

Rate the following goals in terms of their importance to you. List number 1 after the goal that is most important, etc.

1. To provide more leisure time to engage in hobbies, to enjoy good friends and for self improvement. _____

2. To provide an attractive, comfortable and efficient home to meet family needs and happiness. _____

3. To provide the needs of a job or business operation with modern tools, equipment or buildings before improving the home. _____

4. To provide economic security (to be reasonably certain of insuring an income adequate for family needs). _____

5. To provide for the needs of the home, using credit and other income before improving the business operation or job needs. _____

6. To provide financially for good educational opportunities for the children. _____

7. To enjoy good health. _____

8. To provide as much income as possible from a business operation or employment. _____

9. To provide income levels from work which will enable continued enjoyment of it's freedom and independence. _____

10. To help plan and use influence in guiding policies and activities in the city and the county for worthwhile purposes. _____

11. To conserve energy in our farming operation to the extent economically possible. _____

List 5 specific things you wish to accomplish in the next couple of years.

1. _____

2. _____

3. _____

4. _____

5. _____

Name _____

PLANNING THE CROPPING PROGRAM

PART I. Student Objectives

A. Students will be able to identify the influence that cropping programs have on farm income and the proportion of income that is attributable to the crops enterprise.

B. Students will be able to identify at least six important factors that affect crop yields that are manageable.

C. Given a crop planning sheet, students will be able to plan a realistic crop program for their farm that is within the limits of their resources and consistent with their farm

D. The farmer will recognize fertilizer as a large energy consumer in crop production.

PART II. Transition of Units

The last session concentrated on the business of keeping farm accounts current and setting up the home office in a business-like manner. Special emphasis was placed on the necessity of keeping accurate records so that a meaningful business analysis could be devised at year end.

This unit concentrates on another form of record, the cropping plan. Here it is illustrated how historical data on the cropping program is put to use in planning the current crop. The farmer will have to recall past cropping, yield, fertilizer and pesticide treatments to do an effective job of planning. The result of this session should be a cropping plan that combines the elements of goal planning and resource use with the information gained from historical crop program data.

The unit which follows will examine the procedures used in keeping the feed record. Costs of feed, methods of keeping records and the analysis information which will result are all part of the plan.

PART III. The Lesson

Attention Focuser

On a transparency, illustrate the crop table (Table 10) for corn grain (1975, Austin Area), showing only the 179 high and 179 low farms. Use only the first six lines in the illustration. When families have had a few minutes to study the illustration, ask them to help you devise a list of 6-7 key questions you should ask the low profit farms to help them discover why they are not as profitable as the high profit group. Compile a list of the questions on the chalkboard. Point out that you have looked at only one crop, and there are many possible causes for poor performance. It is natural then to lead to the first key questions as to the relationship of the performance of all crops to the profitability of the farm.

2. Native soil capabilities, including drainage
3. Crop rotation and selection
4. Fertilizer and manure use (both prior and present)
5. Varieties
6. Weed and insect control practices
7. Planting rates
8. Disease control
9. Tillage practices
10. Pasture management
11. Timeliness of all operations

Suggested Teaching Strategy

In one of the previous classes, you asked the class to indicate the factors that make total farm earnings vary from farm to farm. Ask the group to try and recall the factors you listed, and to sort out those factors that affect crop yields and the gross return per acre. Give the families a few minutes to jot down some items they recall, or to compile a new list. Call upon several farmers in turn to establish a list of factors that influence crop yields and gross return. List them in two columns on the chalkboard - (manageable and not manageable). When the lists are complete, label the columns manageable and not manageable. Establish the idea that the majority of factors are manageable to some degree. Good management should be reflected in yields and in gross return/acre.

KEY QUESTION 4. What are the energy requirements for the production of fertilizer?

Commercial fertilizer is considered essential today on most farms as a means to make them efficient economic units. Energy sources in the form of fossil fuels which are used in the manufacture of fertilizer are becoming scarce and prices of those fuels are increasing as a result of this scarcity. It is important that we understand how much energy is consumed by fertilizer manufacturers and use for crop production.

The energy used in fertilizer production and use is primarily described by two terms. The first of these is the BTU which is the amount of heat required to raise the temperature of one pound of water one degree f. at standard temperature (32° f.) and pressure (1 atmosphere or 760 mm Mercury). This measure is the British Thermal Unit and is equivalent to .252 kcal which is the metric measure of energy.

Energy for crop fertilizer consumes about one-half of the total energy used for crop production in the U.S.(1) For this reason it is the area of greatest concern. Nitrogen fertilizer which requires ammonia in its production consumes 2% of the total natural gas used in the U.S.(2) One pound of fertilizer nitrogen produced as anhydrous ammonia requires the input of twenty four cubic feet of natural gas(3) which is the equivalent of 6.250 kcal of energy. A slightly higher amount is required for ammonium nitrate. About 58% of the natural gas used in this process provides a source of hydrogen for the ammonia while the balance is used to

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(1) Council for Ag Science and Technology. Energy Use In Agriculture Now and In The Future. Report 68, Ames, Iowa, 1977, p. 3
(2) Hoeft, Robert, Council for Ag Science and Technology. Crop Production, Harvesting and Drying, P. 5, Ames, Iowa, 1977
(3) CAST Report 68. Op Cit. p. 8

provide heat for the process.(4) If we consider this energy in BTU's, the amount to produce a pound of N as fertilizer is about 25,000 BTU per pound. To produce P_2O_5 and K_2O the amount of energy is considerably less at 3000 BTU/lb and 2000 BTU/lb for each respectively. The primary energy expenditure here is for mining.(5)

Additional energy is used for transportation and application of the fertilizer. The energy cost to transport the fertilizer varies by method of shipment. It is estimated that to ship fertilizer by truck requires 4099 BTU per ton mile while for rail and barge the cost of shipment is 1599 BTU per ton mile.

The energy cost of application varies by type of materials. It is estimated to be the highest for anhydrous ammonia which must be incorporated in the soil to avoid volitilization into the atmosphere. There is about 100,738 BTU consumed in the application of anhydrous ammonia per acre.(6)

If the amount of energy in the fertilizer required for one acre of irrigated corn were translated to diesel fuel it would be equivalent to 30.2 gallons of diesel fuel.(7) From this it is apparent that the amount of energy used in the fertilization program is a major portion of that used in crop production.

Suggested Teaching Strategy

The issue of energy is becoming increasingly important as shortages and price increases continue. At the present time, agriculture has a favorable priority position for fuel. Since nitrogen fertilizer is made primarily from natural gas which is also used for heating purposes, the availability of nitrogen fertilizer may be questionable in the future.

This lesson is designed to make the farmer aware of the amount of energy which he is using in the form of crop fertilizer. Have each family compute the amount of energy they are applying in the form of fertilizer per acre of corn using the thumb rules of 25,000 BTU/lb of N, 3,000 BTU/lb of P_2O_5 and 2,000 BTU/lb of K_2O. They can divide this by 140,000 which is approximately the number of BTU's per gallon of diesel fuel. Have them compare this with their estimate of diesel fuel used for their field operations on a per acre basis.

It is important that the farmer does not make rash decisions about fertilizer use on the basis of this information. Returns for unit of energy consumed and practices for conserving energy will be covered in the second and third year units on cropping. As stated earlier, this unit is primarily directed at instilling a degree of energy awareness in the farmer and providing him with some comparative terms for calculating the energy requirements of his cropping program.

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(4) Hoeft, Robert G and Siemens, J. C. Energy Consumption and Return from Adding Nitrogen to Corn. Illinois Research, Vol. 17, University of Illinois, 1975, p. 10

(5)Council for Ag Science and Technology. Potential for Energy Conservation in Agricultural Production. Report 40, Ames, Iowa, 1975, p. 14

(6) Hoeft and Siemens. Op. Cit. p. 10

(7) CAST. Report 68. Op. Cit. p. 13

KEY QUESTION 5. If crop yields can be managed, how does one lay out a crop management plan?

Most good plans start with an inventory of the resources. In the case of crops, this is a plot of the farm with fields and their native capabilities laid out for review. Many farmers will have a map prepared by the S.C.S. which will outline fields and indicate land class and soil type. Others will have to provide their own map if they are to really attack the problem of crop planning.

Noting prior crop history is the second step in the plan. Kind of crop, fertilizer treatment, herbicide use, yields and special seasonal problems are important things to note, since each will have some bearing on the current plan.

Organization of the cropping program should be considered next. Most farmers will need to match the cropping program to the livestock program even though they recognize that good management would usually match in the reverse order - livestock to the cropping program. Because of building facilities, livestock programs are often fixed in the short term, and can be altered only with a major organization of the business.

Establishing yield goals is an important part of the plan. Each crop needs to be examined individually. Given that a certain crop is to be planted on a certain field, what yield should the farmer strive to reach? To answer that question, it is important to consider the following:

1. Capability of the soil

UNIT II - 7

EVALUATING THE CROPPING PROGRAM

PART I. Student Objectives

A. The student will list the management factors used in evaluating the cropping program.

B. The student will describe the importance of each of these factors in evaluating his cropping program.

C. The student will list practices which could improve his cropping program.

D. The student will make recommendations using the list of recommended practices developed for the improvement of his cropping program.

E. The student will evaluate the energy demands and returns of various cropping programs.

PART II. Transition of Units

The previous unit covered the factors found on Table 8 of the Farm Business Analysis and their value as indicators of return to labor and management.

This unit covers the various factors related to the cropping program and their use in evaluating the cropping program. It leads to the evaluation of various practices which are summarized in these factors and recommendations for implementing these practices.

The following unit will deal with a similar evaluation of the supporting enterprises of power machinery and equipment, buildings, fences and tile and how these supporting enterprises affect the income producing enterprises such as crops and livestock.

PART III. The Lesson

Attention Focuser

Place the transparency of the thermometer on the overhead. Ask the class what the temperature in the room is. Someone will soon give an estimate of the temperature. Ask "How should I record the temperature on the thermometer?" After obtaining several suggestions and drawing in lines at several points, point out that unless we have a scale of some sort and that the scale is constant from day to day, year to year and person to person, we really do not know what the "temperature" of our business is. We must have a means, such as the business analysis, which provides a scale of measurement.

Since this class will be held in the middle of the summer, have the class members evaluate their present cropping program for weed control, plant population, crop health and insect control compared to what it was the previous year. This will be discussed more under at-the-farm activity.

KEY QUESTION 4. What are the energy demands and returns of various cropping alternatives?

In recent years the trend of agriculture has been toward larger farms with more intensive use of fertilizer. This is due to changes in crop rotations in which legumes were omitted from the rotation. Intensive fertilizer use has not always been the case nor have our farms always been as productive as they are today.

As discussed in Unit I-6, nitrogen fertilizer is one of the largest consumers of energy in crop production. Historical use of nitrogen fertilizer began after World War II when the price of this fertilizer dropped as the price of petroleum dropped. Prior to this time nitrogen in the soil was built up through the use of legume crops in the crop rotation.(1) Yields improved on crops such as corn and wheat through the use of additional units of fertilizer resulting in greater economic returns. This economic incentive caused usage of fertilizer to rise to its present level.

As energy costs continue to rise, the use of a nitrogen fixing crop such as alfalfa or soybeans in the crop rotation may again become more prevalent. These crops have the ability to produce nitrogen without additional fossil fuel energy expenditures in addition to producing the marketable crop product. Given a 20% increase in energy costs, the increase in corn production costs would be 10.8% while the increase in production costs for soybeans would be only 7.5%.(2)

A number of farms have returned to what may be described as the organic method of farming. Organic simply meaning they do not use any commercial fertilizers or chemical herbicides, insecticides or fungicides. As a result of these practices their crop yields are lower than those of conventional farms but their net return is not too much less since they do not have the added costs. The economics of this is then keyed to variable crop prices, with the situation of high crop prices favoring the conventional producer. The higher yields result in a greater net return over all costs because the gross return per acre is higher.(3)

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1 Hoeft, Robert, Energy Conservation in Agriculture: Crop Production, Harvesting and Drying, C.A.S.T., Ames, Iowa, 1977, p. 13

2 Stanchfield, John, et al, Impacts of Energy Uncertainties on the Food Systems in the Upper Midwest, Upper Midwest Council, Minneapolis, MN, 1977, p. 27

3 Ibid. p. 77

Fertilizer and chemicals constitute approximately one-half of the variable costs in corn production but the return for this investment is from 5 to 10 times its costs.(4)

Contrary to the belief of some organic farmers, the use of commercial fertilizer does not result in soils which are hard, unproductive and difficult to work.(5) The use of commercial fertilizers helps build up soil organic matter through increased production of crop residue. The return of this residue to the soil makes it more friable, tillable and receptive to water.(6) In addition the organic matter decomposes and adds to the fertility level of the soil.

The amount of energy used in the U.S. for agricultural production is about 3% of the total energy use. Of the energy used for crop production in the U.S. corn is the largest overall consumer at about 25% of this energy while wheat, cotton and soybeans consume another 25%.(7)

When we compare the per acre energy requirements of various crops we find that soybeans, alfalfa, wheat and corn are lower than that required for rice and sugar beets. On a per acre basis there are 7.66 million BTU's required for corn production, 2.41 million BTU's required for soybean production and 4.56 million BTU's required for alfalfa production. This compares with 17.65 million BTU's required for rice production and 12.4 million BTU's required for sugar beets. These figures include energy used in the manufacture and transportation of fertilizer and chemicals used in crop production.(8) They are also much lower in energy requirements than that required of horticultural crops such as lettuce, celery and tomatoes. Not only do corn, soybeans, alfalfa and wheat consume less energy on a per acre basis, they return more energy per unit of cultural energy required for production because they are efficient converters of solar energy to food energy.(9)

Despite these efficient uses of energy and the resulting production of energy, costs of production will continue to increase as energy costs increase. Continuous production of corn which does not fix nitrogen in the soil will be the most sensitive of our common agronomic crops to these increases in cost.

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4 Lockertz, William, et al, A Comparison of the Production, Economic Returns and Energy Intensiveness of Corn Belt Farms That Do and Do Not Use Inorganic Fertilizers and Pesticides. CBNS, St. Louis, MO., 1975, p. 2

5 Stanchfield, John, Op. Cit., p. 76

6 Simkins, Charles, Overdahl, Curtis and Fenster William, Fertilizer Use and the Environment, Agricultural Extension Service, University of Minnesota, St. Paul, MN 1972

7 Doering, Otto, et al, Trimming Agricultures Energy Appetite, Farm Index, USDA, Washington, D. C., 1977, p. 9

8 Wynn, N. A., et al, A Guide to Energy Savings for the Field Crops Producer. USDA, Washington, D. C., 1977, p. 3

9 Heichel, G. H. Agricultural and Energy Resources, American Scientist, Vol. 65

Corn is the highest consumer of fertilizer because of its high nitrogen requirement. It is generally recommended on the soils of western Minnesota which have a high clay content that one pound of nitrogen per acre be applied for each bushel of production up to 125 bu/acre and that for over 125 bushels, two pounds of nitrogen be applied as a rule of thumb.(10) Table I compares the fertilizer requirements of several other crops to those requirements for corn on a BTU per acre basis. These requirements are based on recommendations which maintain the fertility of the soil and include production, transportation and application of the fertilizer.

TABLE 1. FERTILIZER ENERGY REQUIREMENTS IN BTU'S PER ACRE *

	Corn	Wheat	Soybeans	Alfalfa
	120 bu/acre	40 bu/acre	50 bu/acre	5 ton/acre
N	3,472,222	1,416,666	--	--
P	307,797	136,904	239,285	342,063
K	127,678	54,761	237,103	1,482,142

* CAST Energy Use in Agriculture Now and In The Future. Report 68. Ames, Iowa 1977, P. 17

Consideration of the amount of energy returned from each unit of input must also be made. It is estimated that corn generates a net of six units of energy for every one unit input as nitrogen fertilizer.(11) Until corn reaches its maximum yield potential, additional increments of nitrogen fertilizer return more energy than it consumes. For example, the first 50 pounds of nitrogen applied return 8.86 units of energy for each unit added. This energy converting potential declines to 1 to 1 as maximum yield potential is arrived at.(12)

The amount of energy stored in one bushel of corn is estimated to be 376,984 BTU's. Because of this high energy return per bushel, the break-even yield of .069 bushels is all that is necessary to compensate for one pound of nitrogen in the form of anhydrous ammonia. To consider applying 100 pounds of nitrogen in the form of anhydrous ammonia, it would be necessary to obtain only a 7.2 bushel yield increase to cover the energy in the fertilizer and for application of the fertilizer.(13) Recent work

10 Nelson, Wally. (Personal Interview) Director, Lamberton Experiment Station, Lamberton, MN, 1979
11 Ibid, p. 17
12 Hoeft, R. G. and Siemens, J. C., Energy Consumption and Return From Adding Nitrogen to Corn. Illinois Research, University of Illinois Experiment Station, Vol. 17, No. 1, 1975, p. 11
13 Ibid, p. 11

at the Southwest Minnesota Experiment Station at Lamberton has shown that the average yield increase based on 18 years of data for the first 95 pounds of nitrogen applied has been 39 bushels per acre.(14) Additional units of nitrogen return less yield per unit applied and thus return less energy per unit of energy applied. The economic principle of diminishing marginal returns holds true for units of energy as well as units of fertilizer.

Energy availability in the form needed to manufacture fertilizer is expected to decrease. Because decreased use of fertilizer represents a trade-off in total food production, it is necessary to determine what cultural practices can conserve soil fertility and still insure adequate production. Discussion of these conservation practices will follow in year three, unit five.

Suggested Teaching Strategy

Have each family calculate the amount of energy they used in their crop production program last year. They can calculate this by taking the number of acres of each crop from their analysis report and multiplying this by the BTU's per acre found in Table II.

Next have them calculate their energy requirements for this crop year. If these requirements have changed ask them what they have done or could do to decrease their energy requirements.

Practices of conserving energy in the cropping program will be discussed in more detail in the cropping unit for year three.

PART IV. Summary

1. There are many factors which can be used to evaluate the cropping program, a number of which are found in the farm business analysis.

2. The business analysis serves as a scale and provides a basis of evaluation for past performance of the cropping program.

3. Based on the more general indicators, specific practices can be listed which will help to improve the program.

4. Various cropping programs require different levels of energy input in the form of fertilizer and also have different levels of energy output. As energy sources become scarce, additional thought must be given to this relationship in planning the cropping program.

PART V. At-The-Farm Activity

Go over the worksheets that were completed in class with each family. Point out areas which you see as weak and those which you see as being strong. Answer questions about specific herbicides, insecticides, fertilizer programs and other crop production practices.

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14 Lamberton Experiment Station, Continuous Corn, Research Report, Southwest Experiment Station, Lamberton, MN, 1978

This is an excellent time to walk over the fields with each operator and determine how successful his crop management program is in the above areas. Population, weed control, disease and insect control, chlorosis problems and many others can be found at this time and recommendations made. Consider the results improved practices as described on the worksheets would have on this years cropping program.

PART VI. Resources

Chalkboard/Overhead
Transparencies of Appendices A, B, C, D
Class quantities of worksheets on enterprise evaluation
Area Analysis Report
Individual family analysis report

PART VII. References

James and Stoneberg. Farm Accounting and Business Analysis. Ames, Iowa: Iowa State University, Rev. 1977.

Persons, Edgar. Documentation for Farm Business Analysis. St. Paul, Minn., Division of Agricultural Education, University of Minnesota, 1977.

Doanes Farm Management Guide. 12 ed. Doanes Agricultural Service, St. Louis, MO., 1978.

Herbst, J. H. Farm Management Principles, Budgets and Plans. Stipes, Champaign, Ill., 1975.

Farm Management Enterprise Analysis and Evaluation, 1975. Division of Agricultural Education, University of Minnesota, St. Paul, MN 1975.

Farm Business Management Area Report, 1973-1977. East South Central Minnesota, Austin AVTI, Austin, MN

PART VIII. Appendices

A. What is the Temperature?

B. Average Costs and Returns

C. Crop Data from Analysis Reports

D. Selected Evaluation Factors

E. Energy Requirements of Field Crops

APPENDIX E

TABLE II. ENERGY REQUIREMENTS OF FIELD CROPS

	MIL. BTU/ACRE
CORN	7.66
GRAIN SORGHUM	7.29
BARLEY	2.92
OATS	1.79
WINTER WHEAT	3.03
SPRING WHEAT	2.29
RYE	2.29
RICE	17.65
SOYBEANS	2.41
FLAX	1.17
CORN SILAGE	7.21
SORGHUM SILAGE	7.04
ALFALFA	4.56
HAY - OTHER	2.34
SUGAR BEETS	12.40

UNIT III - 5

ANALYZING THE CROPPING PROGRAM

PART I. Student Objectives

A. The student will be able to describe ways by which he can change his cropping program to conserve energy in the form of fertilizer.

KEY QUESTION 1. What are the means by which energy can be conserved in the cropping program?

Todays farming operations, as noted in an earlier lesson, require much higher levels of energy input than in previous years. This energy requirement varies from farm to farm but it is generally agreed that large farms have a lower per acre fuel consumption than small farms. Data shows that farms of less than one hundred acres use four times as much fuel as farms over 500 acres.(1) At first this seems to be inaccurate since small farms are usually considered more efficient than large farms. If we consider the nature of these farms we find there would be differences in the type of equipment and management and in the type of productive enterprises with which the farms operate.(2) Based on information about crop energy requirements one can then see that the large wheat farm with a direct crop energy requirement of 3.03 million BTU's per acre would need less energy than the livestock farm which needs energy to operate the livestock facilities as well as the direct per acre requirement of 7.66 million BTU's for corn or the 7.21 million BTU's for corn silage to feed to the livestock. In addition to different enterprises the larger farms may use less energy per acre because they have newer equipment which may be properly tuned up or they have diesel power rather than gasoline for their machinery. It is difficult to make direct comparisons of efficiency since the type of products each of these different size farms is producing is not the same in terms of energy output.

There are numerous means by which energy could be saved in agriculture such as tune-ups of farm engines, changing tillage practices, reducing fertilizer usage plus many others. Until it becomes economically rewarding a large number of these measures will not serve as a practical means of conserving energy. Some measures, such as tuning up farm engines and planning the cropping program to obtain maximum use of the value of fertilizer can be completed with favorable economic benefits at the present time. It is not within the scope of this unit to cover all of these measures so fertilizer, which is the largest consumer of energy, will be dealt with.

To conserve energy in our cropping program through proper fertilizer use, there are six primary areas of concern. The following are means of conserving energy in the cropping program:

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1 Stanchfield, John and Upper Midwest Council. Impacts of Energy Uncertainties on the Food System in the Upper Midwest. Upper Midwest Council, Minneapolis, MN, 1977, p. 22

2 Ibid p. 22

1. Efficient use of commercial fertilizer
2. Applying animal and sewage waste
3. Implementing proper cultural practices
4. Crop rotations which maximize fertilizer value
5. Use of intercropping
6. Supporting crop development programs

A. Efficient Use of Commercial Fertilizer

Since there is a trade off in food production for reduced fertilizer usage, careful analysis of the fertility program must be undertaken. Outright reduction of fertilizer could result in reduced yields and variable expenses not being met. To insure that the proper analysis of fertilizer is being applied, soil samples should be taken following recommended procedures. These samples should be taken from appropriate size plots such as 20 or 40 acres for most crops. At the present time there is an average of only one soil sample taken for every 230 acres of crop production. This is about one-tenth of the recommended number of samples.(3) Once the sample has been taken and recommendations made by a reputable agency, these recommendations should be followed. Also, the yield goal upon which the recommendations are based should be realistic for the climate and soil type under consideration.

Application equipment should be calibrated. Frequently after taking soil samples and interpreting results, time is not taken to properly calibrate the equipment. Under or over application then occurs which may result in injury to the crop in addition to wasting energy in critical periods of shortage.

Method of application is also a factor. Fertilizer applied in a band rather than broadcast also reduces energy demands in a given period of time. Care must be taken not to exceed recommendations for band application since severe plant injury may result from excessive amounts or improper placement. Usually total fertilizer needs can not be met in this manner but application of a portion of the fertilizer in a band as a starter or pop-up fertilizer can increase fertilizer efficiency.

Timing of application may help conserve fertilizer energy depending on climate, soil type and form of fertilizer used.

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3 Wynn, N. A. et al. A Guide to Energy Saving for the Field Crops Producer. USDA, Washington, D. C., 1977, p. 15

Fall application of anhydrous ammonia in Minnesota where soil temperatures drop below 55°f. in early fall results in little loss of nitrogen from volatilization during the winter months on most soil types. Fall application of fertilizer helps avoid the addition of this operation to an already busy spring planting season. Delays during spring application caused by a wet spring or late road restrictions can result in poor yields, which in turn reduce the per unit return from applied fertilizer. However, when there is a possibility of soil temperatures exceeding 55°f. or when the applicator knife trenches will not close or there is a possibility of the nitrogen leaching out of the root zone, application should be delayed until spring to reduce losses.(4)

Current studies at the Southwestern Minnesota Experiment Station at Lamberton show that most of the applied nitrogen which is not removed as grain does not leach out of the root zone. Five years of data with varying application rates up to 400 pounds of nitrogen per acre have resulted in nitrogen "bulges" at various depths in the root zone. The greater the application rate, the larger and deeper the "bulge" of nitrogen in the root zone.(5) The implication of this new data is that for heavier soils, such as those of Southern Minnesota, nitrogen applied at the usual rates and remaining unused by the crop does not leach out of the root zone. This can result in greater carry-over and soil nitrogen buildup than previously thought. New soil test procedures are being developed to test the nitrogen-nitrate level to greater depths than before. Increased energy conservation can then result by maximizing the value of this fertilizer carry-over.

B. Applying Animal and Sewage Waste

There is much discussion in some circles about the merits of organic farming in which no commercial fertilizers, herbicides, insecticides or other chemicals are used in crop production. As discussed earlier, farming by this method usually results in lower crop yields. Organic farmers state the addition of animal manure and crop residues to the soil provide sufficient nutrients for crop production.(6) Animal manure, as known for centuries, is a good source of nutrients. The problem in relying on it on a nationwide basis is that there is only enough collectable manure to fertilize 18% of the U.S. cropland at adequate levels. In addition, if sewage sludge is relied on as a

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4 CAST, Potential for Energy Conservation in Agricultural Production, Report 40, Ames, Iowa, 1975, p. 15

5 Nellson, Wally (Personal Interview) Director, Southwest Minnesota Experiment Station, Lamberton, MN., 1979

6 Lockertz, William, et al. A Comparison of the Production, Economic Returns and Energy Intensiveness of Corn Belt Farms That Do and Do Not Use Inorganic Fertilizers and Pesticides. C.E.N.S., St. Louis, MO, 1975, p. 6

source of nutrients for crops, there is only enough to fertilize an additional 1% of the cropland.(7)

Although manure can not be relied on as the sole source of nutrients, it can be used as a supplement to reduce fertilizer energy demands. As energy costs continue to climb, new methods of manure storage and handling will be devised to conserve nutrient value.

Efforts also should be made to return the maximum amount of crop residues to the soil. If stover or straw is sold from the farm, the price for this product should reflect the value of the additional fertilizer necessary to replace the fertilizer value of the residues. The value of the organic matter can not be replaced. Also, burning of crop residues as still practiced in some areas should be eliminated to conserve this source of fertilizer energy.

C. Implementing Proper Cultural Practices

The use of proper cultural practies and timeliness of operations can conserve fertilizer energy by increasing energy output per unit of cultural energy required for production.

Weed control is one of the most important cultural practices for improving crop yields. Weeds compete with crops for moisture and nutrients, thereby reducing potential yields. Energy loss occurs from this nutrient uptake of the weeds as well as by the reduced energy output in the form of crop product. Effective weed control can thereby reduce fertilizer energy requirements for a crop when compared to the same crop in a weedy field.

Timeliness of operations can also be an important factor in reducing the amount of energy required per unit of output. Most often it requires the same amount of energy input regardless of when the operation is performed. However, as operations are delayed, especially planting and harvesting, yields are reduced and energy output is also reduced. Corn yields are often reduced a bushel a day per acre between May 1 and mid-May. After the first of June the yield loss may increse to 3 bushels a day per acre. Yield losses of up to 20% have occurred in attempts to field dry corn to 17% moisture content. Aditional losses may occur as a result of early snow.(8)

The effect of proper cultural practices is primarily to make fertilizer use, and thereby energy use, more efficient. In times when fertilizer may be in short supply due to alternate

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7 Hoeft, Robert. Energy Conservation In Agriculture Crop Production, Harvesting and Drying. CAST, Ames, Iowa, 1977, p. 13

8 CAST Report 40, Op. Cit. p. 18

demands for energy, proper cultural practices can help maintain yield by stretching the nutrient value of that fertilizer which is available.

D. Crop Rotations Which Maximize Fertilizer Value

Crop rotation was at one time the primary method of maintaining soil fertility. Legume crops such as alfalfa and clover were used to add nitrogen and organic matter to the soil. With the advent of ammonia production from petroleum products, nitrogen fertilizer became more available and economical to use. Consequently many cropping programs omitted legumes in the rotation.

It is estimated that if alfalfa or clover are added to the rotation, nitrogen application for the following crop could be reduced by as much as 100 pounds per acre. The amount contributed by soybeans is somewhat less.(9) In most cases, this contribution will not be enough to meet the requirement of a crop such as corn.

A second problem arises from the market value of many of the legume crops. In most cases they are forages and their market value is limited. Soybeans has shown excellent per acre return over the last several years but its nitrogen fixing capability is much less than that of alfalfa or clover. The usefulness of a legume in the crop rotation will depend on energy costs and crop prices. It should not be overlooked as a means of supplying needed nutrients in a manner requiring little energy input in the form of fertilizer.

E. Use of Intercropping

In recent research the practice of intercropping has been investigated. This is simply the practice of planting a leguminous crop between the rows of a nonleguminous crop. Data available indicates that from 50 to 100 pounds of nitrogen per acre can be supplied by this method. As with nitrogen furnished by legumes in the crop rotation, the amount is not adequate for crops such as corn. If nitrogen is added in the form of fertilizer the legume crop will use this supplemental nitrogen before fixing atmospheric nitrogen. The result is little reduction in the amount of fertilizer needed.(10)

Another problem with intercropping is that yields of the nonleguminous crop are seldom greater (and are often less) than those of the same crop produced without intercropping. This is a result of competition for soil moisture. In some

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9 CAST. Energy Use in Agriculture: Now and For the Future. Report 68. Council for Ag Science and Technology. Ames, Iowa, 1977, p. 18

10 Ibid. p. 18

areas where yields are consistently lower, intercropping may produce adequate nitrogen to meet crop needs.(11) Additional study needs to be done before this can be considered an economical practice in Minnesota.

F. Supporting Crop Development Programs

Some experimental work has been done in plant breeding to produce nitrogen fixing abilities in nonleguminous crops. These studies are in their early stages and there are no favorable results evident in the immediate future.(12)

The long term benefits of such studies could greatly reduce energy needs in the form of nitrogen fertilizer if they are successful. For this reason support of crop development programs through land grant colleges and commercial seed companies should be encouraged.

<—— This unit is the culmination of the discussion of fertilizer energy demands for crop production. The broad scope of energy use in fertilizer production and use has been narrowed down to efforts which the farmer can participate in. The practices listed will help the farmer insure maximum production while reducing the amount of fertilizer energy consumed. These practices do not and should not discourage fertilizer use but rather should promote sound management practices which make maximum use of available fertilizer energy. In times of fertilizer shortage, alternative cropping programs which utilize the nitrogen fixing ability of legumes may be resorted to. These programs should be designed to encourage soil fertility maintenance and thereby reduced energy needs for the following crops. The use of animal waste and development of efficient waste handling systems can be a valuable source of fertilizer on many farms. Additional research of new crops and cropping methods are needed to promote continued production in the face of increasing energy costs and declining availability of products demanding high energy inputs such as fertilizer.

Although production agriculture demands only 3% of the U.S. energy requirement, the type of energy consumed is in the form which is being competed for by many segments of the economy. It will be up to the farmer to plan his cropping program effectively to maintain necessary levels of production in the face of this adversity.

Suggested Teaching Strategy

Display the transparency of Appendix A on the overhead and ask the farmers to contribute practices in each of the areas listed. Following this discussion distribute the checklist, Appendix B, to each class member. Ask them to check those items which they can practice this

year. On the next farm visit go over the checklist with them to see if there are any other ways which you might see to conserve energy through effective crop management.

The group should be aware of the role energy and energy costs play in their crop production program at the close of this session. If the previous units were taught in years one and two, a review of the scope of energy use in agriculture may be necessary as well as a review of the energy demands and returns from various crops.

PART II. Summary

There are a number of practices which a farmer can implement at the present time which will conserve energy and are economically feasible. These include soil testing, following soil test recommendations, utilizing fertilizer carryover, timeliness of cultural operations and making use of available animal manure and crop residue.

APPENDIX A

MEANS OF CONSERVING ENERGY IN THE CROPPING PROGRAM

A. EFFICIENT USE OF COMMERCIAL FERTILIZER

B. APPLYING ANIMAL AND SEWAGE WASTE

C. IMPLEMENTING PROPER CULTURAL PRACTICES

D. CROP ROTATIONS WHICH MAXIMIZE FERTILIZER VALUE

E. USE OF INTERCROPPING

F. SUPPORTING CROP DEVELOPMENT PROGRAMS

APPENDIX B

CHECKLIST OF PRACTICES TO CONSERVE FERTILIZER ENERGY

_____ SOIL TEST

_____ APPLY RECOMMENDED QUANTITY OF FERTILIZER

_____ APPLY RECOMMENDED ANALYSIS OF FERTILIZER

_____ CHECK THE CALIBRATION OF APPLICATION EQUIPMENT

_____ COMPARE PREVIOUS YIELD TO YIELD GOAL TO DETERMINE POSSIBLE CARRYOVER IN THE ROOT ZONE

_____ PROVIDE MANURE HANDLING FACILITIES TO INSURE MAXIMUM FERTILIZER VALUE

_____ RETURN CROP RESIDUES TO THE SOIL

_____ MAINTAIN PROPER WEED CONTROL

_____ APPLY FERTILIZER AT A TIME WHICH WILL REDUCE LOSS ON MY SOIL TYPE

_____ COMPLETE PLANTING AND HARVESTING OPERATIONS IN A TIMELY MANNER

_____ PLAN LEGUME CROPS IN THE CROP ROTATION

_____ ROTATE CROPS TO MAKE MAXIMUM USE OF NITROGEN PROVIDED BY LEGUME CROPS

_____ PRACTICE INTERCROPPING IF APPROPRIATE FOR MY AREA